Hybrid Precipitated Calcium Carbonate Containing Wood Flour for Paper Applications– A Comparative Handsheet Study

ABSTRACT

The main objective of this paper handsheet study is to investigate if a hybrid filler material containing wood flour and precipitated calcium carbonate can replace and/or supplement commercial available ground calcium carbonate and precipitated calcium carbonate mineral filler material for papermaking. The handsheet study contains 25 different furnish mixtures. Four different types of wood flour were used to manufacture the hybrid filler material, including two blends with a strengthening agent. All handsheet were manufactured with an 80% harwood and 20% softwood mix. The filler content varied between 10, 15 and 20%. The study showed that the hybrid filler material achieved a retention of up to 92.68% as well as higher caliper of up to 208 μm compared to commercial ground and precipitated calcium carbonate of 120.4 μm and 145.6 μm respectively. Tensile and tear strength did not show an improvement. Elongation and TEA did improve of up to 30% with the strength additive containing hybrid filler material. Opacity was improved of up to 10% with the hybrid filler material. Brightness and color values were lower due to the natural brow color of the wood flower material.

Keywords: Wood flour, filler, PCC, GCC, additive, strength, retention, papermaking, handsheets, paper properties

1. INTRODUCTION

In the last decade, worldwide efforts in technology and society have been made to find ways to replace ephemeral plastic products with environmentally friendly materials. A promising product with a wide range of uses is paper. In order to further increase its ability to compete with established plastic products, the paper-making process must also be viewed critically with regard to the use of energy and raw material usage [1]. The following work focuses on the replacement of mineral fillers with Wood Flour (WF). The filler to be replaced in this study is calcium carbonate in the form of Ground Calcium Carbonate GCC and Precipitated Calcium Carbonate PCC, the most commonly used filler material in papermaking [2]. The share of mineral filler in the total raw material input of the paper industry is currently 8%. However, the trend of recent years shows a clear trend towards the production of papers containing higher filler [3].

The application of GCC and PCC mineral filler material in the paper manufacturing process lowers production cost due to the lower cost of filler to raw fiber material [2, 3]. The application of filler materials increase optical properties such as whiteness, brightness, and opacity and can have a positive impact on formation [5].

GCC occurs by the degradation of calcium carbonate. This is a naturally occurring material whose raw stone is extracted from chalk, lime and marble deposits. A great difference to other fillers are its rhombohedral calcite crystals. After several comminution steps and removal of the chemical impurities by flotation, the final particle size distribution is achieved by micronization. Solid contents of the commercial slurries of GCC are about 78% [3].

36 PCC, on the other hand, belongs to the group of synthetic carbonates, which are obtained
37 through a three-stage process. First, quicklime is produced by thermal removal of CO_2.
38 Subsequently, the quicklime is converted with H_2O to calcium hydroxide. The reintroduction
39 of CO_2 causes the precipitation of PCC at a solids content of 20-35%, much lower than
40 comparable GCC slurries [3].
41   Since the beginning of the twentieth century, wood flour has been used as an
42 extender for glue and absorbents of explosives. As a filler in the production of plastic parts,
43 wood flour was first processed in 1916. [6] The term "wood flour," for which no clear-cut
44 definition has been adopted, is applied somewhat loosely to wood reduced to finely divided
45 particles approximating those of cereal flours in size, appearance, and texture. A specific
46 method of production is not involved in the name "wood flour." [7] Practically speaking, wood
47 flour usually refers to wood particles that are small enough to pass through a screen with
48 850-micron openings (20 US standard mesh) [7]. Earlier studies have shown that the use of
49 wood flour can be an alternative cellulosic based wood additive [8]. A deterioration in
50 brightness and smoothness could be compensated by the combined use with calcium
51 carbonate. [9]
52
53 **2. MATERIAL AND METHODS**
54
55 This section describes the materials, standardized TAPPI test methods, and procedures,
56 used for this study. Repeatability of the results stayed in between the allowable margins of
57 the TAPPI testing standards.
58
59 **2.1 TAPPI Methods**
60 Pulp refining was done according to T 200 sp-06 "Laboratory beating of pulp (Valley beater
61 method) [10], Handsheets for physical testing were prepared accordance with T 205 sp-06
62 [11], As was tested with T 211 0m-02, "Ash in wood pulp, paper and paperboard:
63 combustion at 525°C" [12].
64 Physical testing of handsheets was performed in accordance to T 220 sp-06, "Physical
65 testing of pulp handsheets" [13], the freeness of pulp was measured as Canadian Standard
66 Freeness (CSF) according to T 227 om-09 "Freeness of pulp (Canadian standard method)"
67 [14].
68 Conditioning of the paper samples was done according to T 402 sp-08, "Standard
69 conditioning and testing atmospheres for paper, board, pulp handsheets, and related
70 products" [15]. Tensile strength was measured in accordance with T404 cm-92, "Tensile
71 breaking strength and elongation of paper and paperboard" [16]. Basis weight was
72 measured with T 410 om-08. "Grammage of Paper and Paperboard (weight per unit area)"
73 [17]. The paper thickness was measured by T 411 om-10 "Thickness (caliper) of paper,
74 paperboard, and combined board" [18]. The moisture content of pulp was determined by
75 T412 om-06 "Moisture in pulp, paper and paperboard" [19]. The tear strength was done by
76 following the T 414 om-12, "Internal tearing resistance of paper (Elmendorf-type method)"
77 [20]. The opacity of paper handsheets was performed according to T 425 om-06, "Opacity of
78 paper (15/d geometry, illuminant A/2°, 89% reflectance backing and paper backing) [21].
79 Brightness of pulp was measured according to T 452 om-08, "Brightness of pulp, paper and
80 paperboard (directional reflectance at 457 nm)" [22]. Stiffness of the paper was measured
81 according to T 489 om-08, "Bending resistance (stiffness) of paper and paperboard (Taber-
82 type tester in basic configuration)" [23]. The paper color was measured by T 524 "Color of
83 paper and paperboard" [24].
84
85 **2.2 Materials**
86 For the handsheet study the fiber materials used was a blend of 80% Sappi Saiccor
87 Eucalyptus Hardwood and 20% AV Terrace Bay Northern Bleached Softwood Kraft [NBSK].

88   The furnish was beaten to a 320 ml TAPPI CSF freeness in a valley beater following TAPPI
89   T 200 sp-06method [9].
90   For the study, two different commercially available GCC and PCC types were used. The first
91   GCC [GCC1] used was a GCC powder with a mean particle size of 0.7 μm. A 20% slurry
92   using deionized water was produced for the application in the handsheets. The second GCC
93   [GCC2] applied to the handsheets was a commercially available GCC slurry with 76.72%
94   solids content with a mean particle size of 0.73μm.
95   The first PCC [PCC1] used was a PCC powder with a mean particle size of 1.0 µm to 2.0
96   µm. A 20% slurry using deionized water was produced for the application in the handsheets.
97   The second PCC [PCC2] applied to the handsheets was PCC slurry produced on-site at a
98   paper mill site in the U.S. with 19.58% solids content and a mean particle size of 1.66 µm.
99   For the second trial four different precipitated calcium carbonates (PCC) + Wood Flour (WF)
100   were produced and integrated into the handsheets.
101   To produce the laboratory hybrid WF-PCC a calcium hydroxide ($Ca(OH)_2$) type was used
102   suitable for PCC production in combination with two WF types with and without Strength
103   Additive (SA) that is activated contact drying. WF1 had a particle size distribution of 20µm to
104   50µm and WF2 had a particle size distribution of 40µm to 70µm.
105   The produced hybrid WFPCC1 to a solids content of 14.35%, WFPCC1SA 16.99%,
106   WFPCC2 13.28%, and WFPCC2SA 16/35%.
107

2.3 PCC + Wood flour material preparation

109   The preparation of the PCCWF product followed the process sequence laid out in Figure 1
110   which shows the flow of the production process with all components and important data. A
111   Fischer Scientific Isothemp Lab Stirring Hotplate was used for stirring and heating the
112   suspension in a 2000 ml beaker. Industrial grade CO_2 from a 150 lbs. gas bottle with
113   pressure regulator was used as the precipitation reactant. The CO2 was dispersed in the
114   beaker with an air stone.
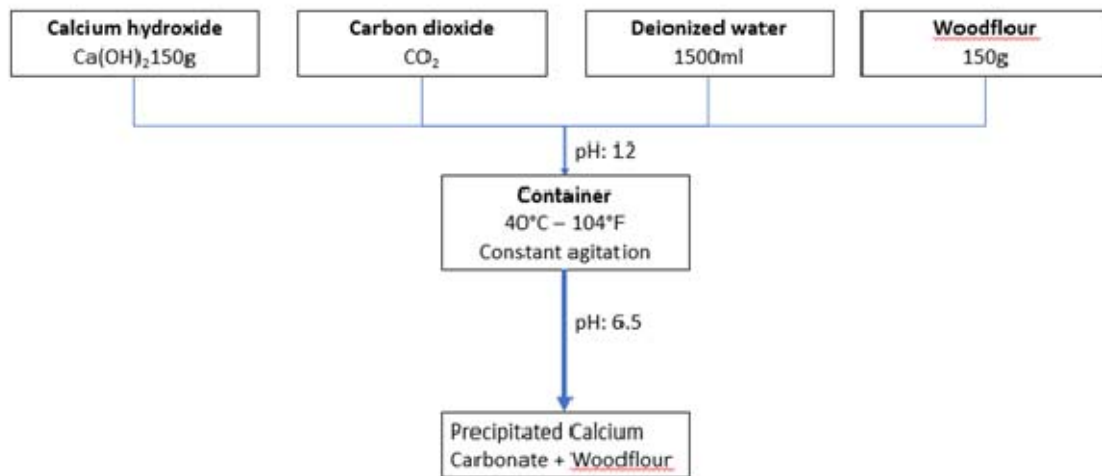
115
116
Fig. 1. PCC+ WF process sequence

118
119   The preparation of the material started with the weighing of 1500 ml of deionized water 150g
120   Calcium di-hydroxide $Ca(OH)_2$ and 150g of the respective wood flour (Figure 2a). The next
121   process step is heating water to 40°C. Subsequently, first GCC and the respective wood
122   flour was added one after the other. In order to avoid clumping and to ensure good mixing,
123   slow addition of the powders and constant agitation was necessary (Figure 2b). After that the
124   addition of CO_2 could be started (Figure 2c). The amount of added CO_2 was determined
125   visually, because the wood flour foamed strongly when too much was added. (Figure 2e).

126 Once the amount was set, it was left constant. Throughout the process, the temperature and
127 pH were measured with a pH meter (Figure 2d). The initial pH value was 12.0. The
128 measurement of pH was important because it was the indicator for the precipitation of PCC,
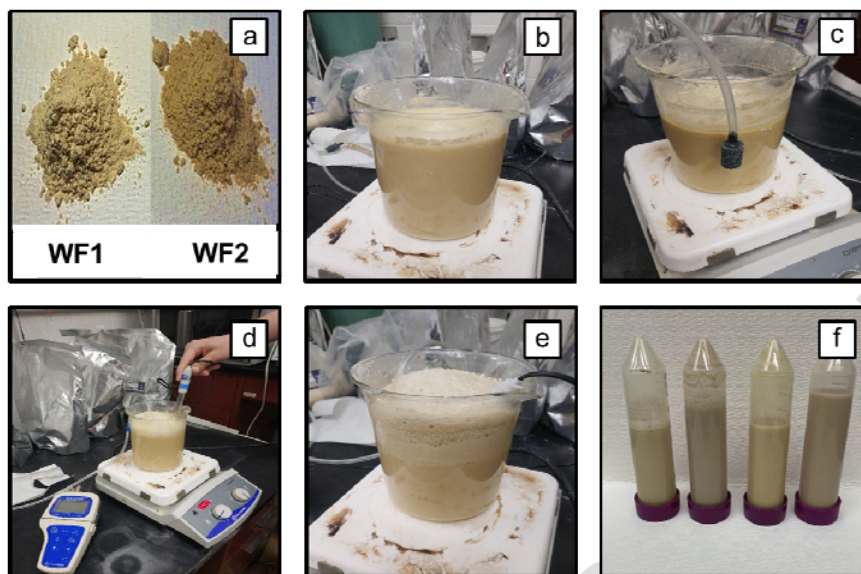129 the target value of the pH after precipitation was set to a pH of 6.5.
130

131
**Fig. 2. PCC Production with WF a) WF types, b) WF-CA(OH)$_2$ slurry, c) CO$_2$ injection
system d) pH and temperature measurement, e) foam built up f) final PCCWF from left:
WFPPC1, WFPCC1SA, WFPCC2, WFPCC2SA**

135
136 Figure 3 shows that all four blends start with the same initial values (pH 12.0, 40°C) and
137 follow the same pattern throughout the process. During the first phase of the reaction the pH
138 stays constant while the temperature increases quickly until a maximum is reached. Striking
139 here is the difference of the length of this phase. The precipitation of WFPCC1 and
140 WFPCC1SA reached a temperature 56°C is after 33 minutes, and 54°C after 36 minutes
141 respectively. For WFPCC2 and WFPCC2SA precipitation a temperature a maximum
142 temperature of 55°C and 52°C was reached respectively. The total precipitation time was
143 between 37 and 47 minutes. As soon as the maximum temperature was reached, the pH
144 level dropped in less than three minutes to the target value of pH 6.5 and the CO$_2$ influx was
145 turned off. After continuing stirring for 2 minutes without adding more CO$_2$, the pH levels
146 stabilized around 6.8. The finished slurries were bottled and stored in a cold room at 5°C.
147 Figure 2f shows the color differences of the produced WFPCC slurries from left to right:
148 WFPCC1 with 14.35 % solids content, WFPCC2 with 14.28% solids content, WFPCC1 with
149 16.99% solids content, and WFPCC2SA with a 16.53% solids content. Noticeable is the
150 lighter color of the WF1PCC after precipitation.
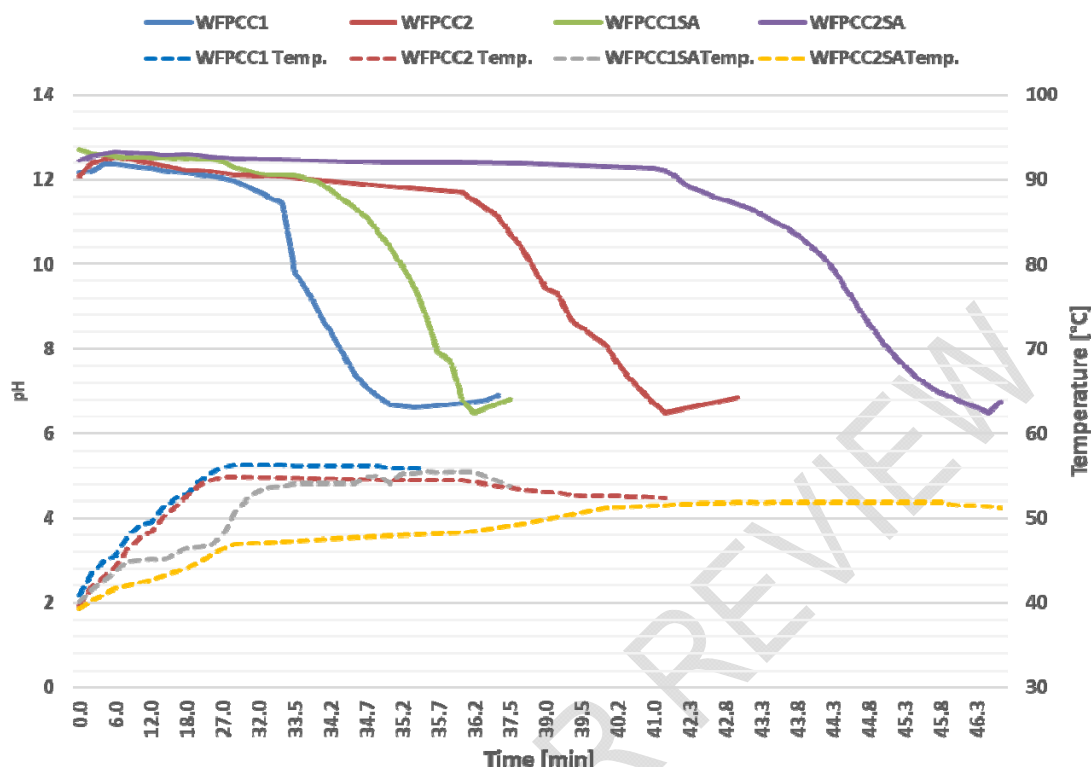151
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Fig. 3. Process temperature and pH during laboratory PCC production

2.4 Handsheet study

All handsheets contained the same amount of fiber (80% SW and 20% HW) for the base line and the eight filler varieties described above. The target for the basis of the handsheets was 85 g/m². The amount and type of filler was changed in every furnish. The handsheets consisted of a filler variation from 0%, 10%, 15% and 20% for every filler type that was used. From each variety five handsheets were formed.

The beating of the SW/HW pulp was done in accordance with TAPPI T 200 with a consistency of 1.57±0.04% and a temperature of 23±2°C. The pulp was loaded into the Valley Beater, the Valley Beater was operated with no load for 3 min. After that, the initial sample was taken, and the beating was initiated by applying a weight of 5500g to the grinding plate lever. The pulp was refined to CSF value of 320. After the pulp is refined, handsheets are made to the composition mentioned above and tested according to TAPPI standards. When weighing the fillers, it was important to note that the slurries in the bottles were well mixed and all deposits on the bottom were released. Then the weighed fillers were added to the fiber suspension and stirred for about a minute. Subsequently, the handsheets were formed, pressed and conditioned in the laboratory. The sheets which contained strengthener were contact dried after pressing at 120°C for 5 minutes on both sides.

3. RESULTS AND DISCUSSION

All handsheets were tested for basis weight, caliper, stiffness, tear, tensile, elongation, TEA, opacity, brightness and L-/a-/b-values according to the TAPPI testing standards mentioned above and compared to a basis sheet consisting only our fiber blend without the addition of any filler.

3.1 Retention

Figure 4 displays the differences, regarding retention, between the eight filler types. For determining the level of retention, we averaged the amount of ash of all three handsheets (10%, 15%, 20% target filler value) which were produced using the same filler. One of the most important parameters of our handsheets was the exact loading of certain quantities of filler. Only by achieving constant amounts of filler, the physical properties of the handsheets can be compared with each other. Based on experience on filler retention in handsheet molds and the knowledge about the much poorer retention, handsheets were first produced with eight times as much filler as to determine the actual retention and to adjust the dosage factor.

Comparing the GCC powder and the GCC slurry, the powder had a three times higher retention rate than the slurry (8.66% versus 2.58%). In contrast, the PCC powder and the PCC slurry show a nearly identical behavior (34.32% and 34.77%). In addition, PCC shows better retention than GCC. The reason for this is probably the larger surface, the larger particle size and more branched structure of the PCC.

The PCC slurries produced together with the WF have a significantly higher retention than the pure PCC. The integration of wood flour into the filler offers the possibility of hydrogen bonds between the filler particles and the fibers of the paper.

This does not exist with pure inorganic filler. It is noticeable that the type WFPCC1 has a retention of 82.98% much higher than the type WFPCC2 with 51.51%. The reason for this could again be the larger particle sizes of the WF product.

The best retention of 92.68% was achieved by using WFPCC1SA. THE WFPCC2SA also showed a an increased retention of 79.13% compared to the commercial available filler materials, but lower retention compared to the WFPCC1 product.
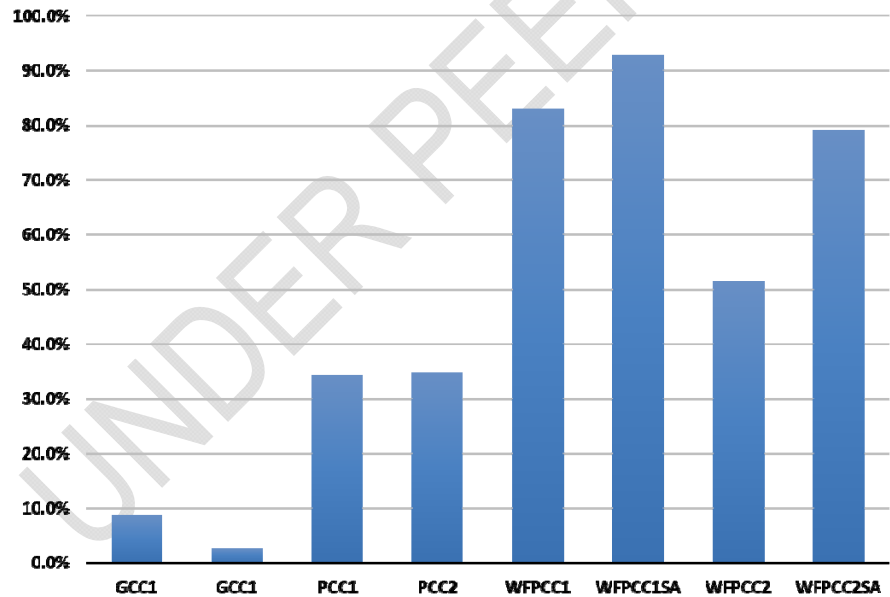

Fig. 4. Filler retention

3.2 Caliper, Basis weight, Stiffness Index

For comparison of the basis weight, the base sheet had 87.54 g/m². The PCC1 handsheet had a basis weight of 87.18 g/m² comparable to the GCC1 basis weight of 85.65 g/m². GCC2 hansheets had a basis weight of 80.94 g/m² and 92.22 g/m² for PCC2. For

216 handsheets manufactured with wood flour the basis weight had a range of 107.31 g/m²
217 (WFPCC1) to 117.03 g/m² (WFPCC2).
218 The caliper of the basis sheet and the sheets with GCC filler had comparable properties of
219 128.8 μm and 120.4 μm (GCC1) and 119.2 μm (GCC2) μm respectively. The handsheets
220 with the PCC as filler had slightly higher caliper in the tests. The PCC1 had a caliper of
221 145.6 μm comparable to the PCC2 with 142.8 μm.
222 The produced handsheets with wood flour showed different caliper depending on the used
223 WF. It was noticeable that PCCWF2 with distance showed the highest caliper with 268 μm.
224 WFPCC2SA + WFPCC1SA had comparable values of 198 μm and 208 μm. The lowest
225 caliper was achieve had WFPCC1 with 185 μm, which is still higher than that of the purely
226 inorganic fillers and the basis sheet.
227 The resulting stiffness index was higher for the basis sheet (0.123) and lower for all other
228 filler except WFPCC2 (0.127). In general, the stiffness of each filler remained about the


229 same. The range was between 0.096 and 0.107 after calculating the index.
230 **Fig. 5. Basis weight/ Caliper/ Stiffness 15 % filler + WF**
231
232 The high retention of the wood flour + PCC filler resulted in a final ash content of 15% for the
233 10% handsheet series. Accordingly, all other test series were well above their targeted ash
234 content. In order to ensure a comparability, only sheets with the same amount of filler were
235 compared with each other. Since the proportion of fibers was not adjusted to the
236 unexpectedly higher retention, higher basis weights resulted accordingly.
237 A direct result of higher fiber content and thus higher basis weight is a higher caliper. An
238 additional factor for a higher caliper in contrast to the base sheet is the generally larger
239 particle size of the wood flour and the possibility of swelling the wood particles. In order to
240 compare strength properties despite different basis weights, an index was calculated. Due to
241 the higher volume of wood flour in contrast to the PCC or GCC, the stiffness of WFPCC2 is
242 comparable to the base sheet. Overall, the wood flour has hardly any influence on the
243 stiffness in the finished paper.

244 All tests were repeated with 20% filler sheets to reproduce the previous results that are
245 shown in Figure 6. By a higher proportion of wood flour, any influences are to be displayed
246 more clearly. Additionally, two sets of handsheets were made containing both WF with and
247 without SA, which required contact drying. These handsheets were examined by all the
248 above test methods to find the differences that contact drying makes.
249 Both basis weight and caliper have increased as expected due to the higher filler load. The
250 stiffness has not changed compared to 15%. The activation process of the SA shows no
251 influence on caliper and stiffness.
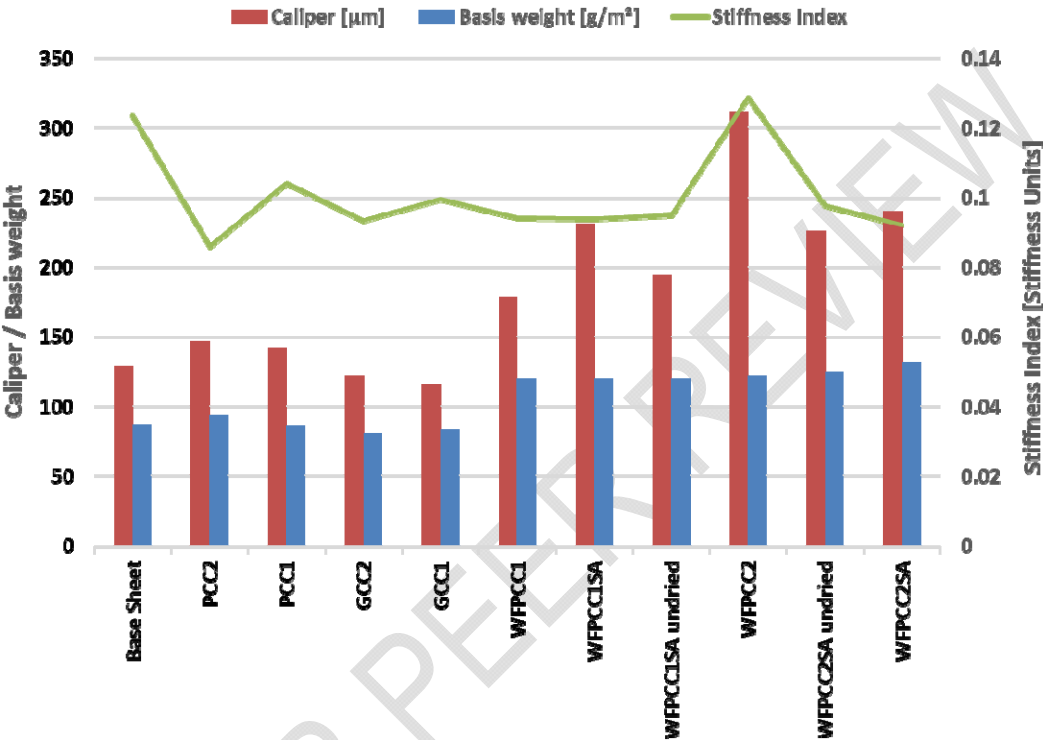
252
253 **Fig. 6. Basis weight/ Caliper/ Stiffness 20 % filler + WF**

254
255 **3.3 Tensile Index and Tear Index**
256 The tensile and tear index in Figure 7 shows a consistently strong correlation. The base
257 sheet has the highest tensile and tear index values (0.69 / 6.07). Adding filler of any kind
258 significantly reduces these strengths. Both PCC2 and PCC2 have comparable values of
259 (0.22/4.76 and 0.22/4.94). When using GCC as the filler, slightly higher values can be seen
260 in the tensile and tear index (0.32/5.40).
261 Adding wood flour to the furnish while replacing fibers, lowers the tensile and tear index
262 significantly. Including a SA to the WFPCC shows slightly higher values in comparison
263 without SA. WFPCC1 shows values of tensile and tear index 0.30/4.31 and 0.31/4.64 with
264 SA. WFPCC2 shows values of tensile and tear index of 0.26/4.32 without SA and 0.31/4.93
265 with SA.
266 With the use of 20% filler, Figure 8 shows identical results as Figure 7, whereby the
267 individual values have a lower value in comparison to the base sheet. Not to be expected
268 were the higher strength values of the handsheets with strengthener without contact drying.
269 WFPCC1SA with contact drying had tensile index values of 0.23 and without drying 0.30.
270 The tear index was 3.84 with drying and 4.23 without. WFPCC2SA with contact drying had

271   tensile index values of 0.22 and without drying 0.24. The tear index was 3.22 with drying and
272   3.46 without.
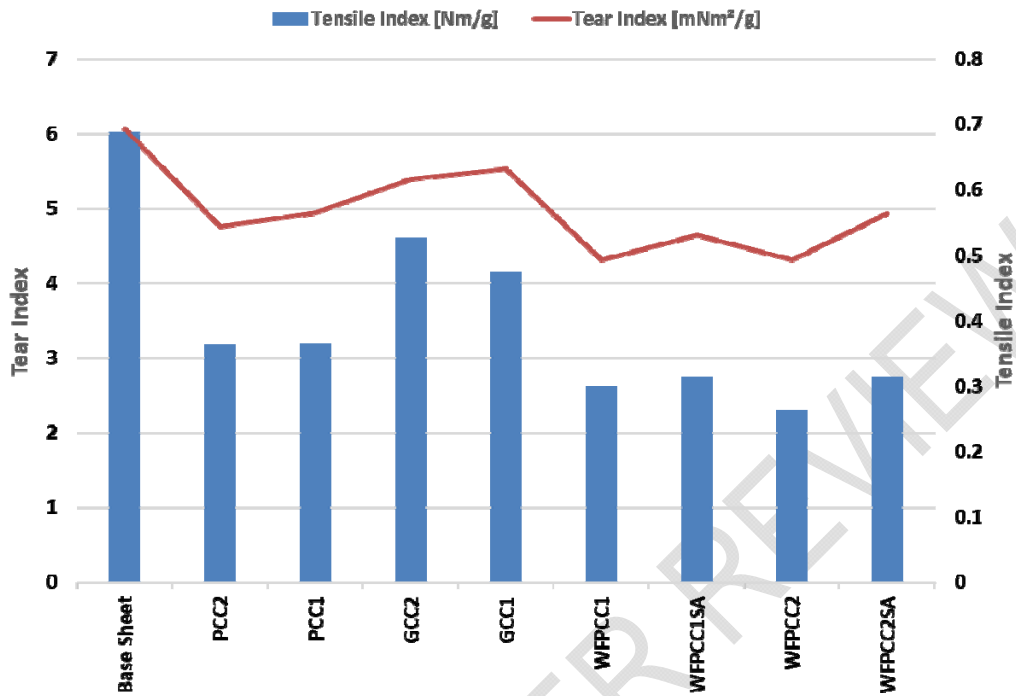
273   **Fig. 7. Tensile / Tear 15% filler + WF**

274
275   **Fig. 8. Tensile / Tear 20% filler + WF**

3.4 Elongation and TEA

Figure 9 shows elongation and TEA (Tensile Energy Absorption) at 15% filler. The base sheet had a maximum elongation of 1.91% and a TEA of 3.27. In comparison to that, PCC2 values were 1.76% and 1.57 and PCC1 values were 1.94% and 1.75 respectively. GCC2 and GCC1 results were also very close, 1.68% versus 1.72% regarding elongation and 2.10 versus 1.94 regarding TEA respectively.

WFPCC1 without strengthener has similar values to pure mineral fillers, 1.54% elongation and 1.49 TEA. Adding SA results in an elongation higher than the basis sheet (2.45%) as well as a far less reduced TEA value of 2.32. The positive influence of the strengthener with the bigger wood flour particle size of FLPCC2 is even higher; the TEA value of 3.28 is on the same level as the basis sheet (1.45 WF without SA). The elongation is, with 3.13% more than 30% higher than the maximum elongation of the basic sheet (1.45% WF without SA).

Fig. 9. Elongation / TEA 15% filler + WF

Figure 10 shows that increasing the amount of filler from 15% to 20% changes the influence of the wood flour and the additional strengthener drastically. The pure mineral fillers show a loss of strength in the paper at an increased input. It is noticeable that the use of PCC (1.76%) leads to higher elongation values compared to GCC (1.61%). GCC (1.66), on the other hand, shows a lower decrease in TEA than PCC (1.57).

The use of wood flour shows even an greater decrease in relation to elongation and TEA. It can be seen that the wood flour with strengthener exhibit both higher elongation and TEA in the paper. WFPCC1 (1.43% versus 0.88) compared to WFPCC1SA (2.55% versus 2.08). WFPCC2 (1.63% versus 1.37) has also lower values than WFPCC2SA (2.18% / 1.85%). Overall, both values are reduced compared to the use of 15% filler.

303 However, regarding this strength characteristic, it is striking that the activation of the SA by
304 contact drying has a positive effect. Both the elongation and the TEA show higher values

305 after contact drying than when using the same wood flour without contact drying.
306 WFPCC1SA without drying shows elongation of 1.50% and a TEA of 1.53. WFPCC2SA
307 without drying shows elongation of 2.07% and a TEA of 1.79.
308 **Fig. 10. Elongation / TEA 20% filler + WF**
309
310 **3.5 Brightness and Opacity**
311 This section describes the results of the optical examinations. Figure 11 shows the
312 comparison of all fillers used in terms of opacity and brightness. Figure 11 only shows the
313 measured values in the use of 20% filler.
314 As expected, when using mineral fillers, both the opacity and the brightness in the paper
315 increase in comparison to the basis sheet. The base sheet had an opacity of 85.76 and a
316 brightness of 86.91. When PCC was used, the opacity and the brightness increased. For
317 PCC2 a value of 93.41 for opacity and 91.82 for brightness was achieved. When using
318 PCC1 a value of 90.72 for opacity and 90.27 for brightness was achieved. GCC2 showed
319 little differences in the values of 88.37 opacity and 89.65 brightness. When using GCC1 a
320 value of 89.62 and 88.59 was achieved was achieved for opacity and brightness
321 respectively.
322 When using PCC + wood flour mixtures, the brightness dropped drastically while the opacity
323 increased significantly. The loss of brightness can clearly be traced back to the naturally
324 darker and unbleached wood flour. The increased opacity can be explained by the increased
325 use of fine material. When comparing the two types of wood flour it was noticeable that the
326 opacity was not dependent on the grade but on the amount of wood flour used. The
327 brightness was higher when using the WF1with smaller particle size than WF2 with the
328 larger particle size.
329 There were hardly any differences in brightness and opacity within the WF grades. The
330 values range between a minimum brightness of 62.91 and a maximum of 64.13. Regarding
331 opacity the minimum value is 98.34 and the maximum 100.46.

332 WFPCC2 opacity values are very similar, ranging from 98.98 to 100.11. When comparing
333 brightness, the handsheets produced without SA occurs darker (57.35) than the handsheets
334 containing WFPCC2SA a (62.08 undried and 61.82 dried) which are very similar.
335
336
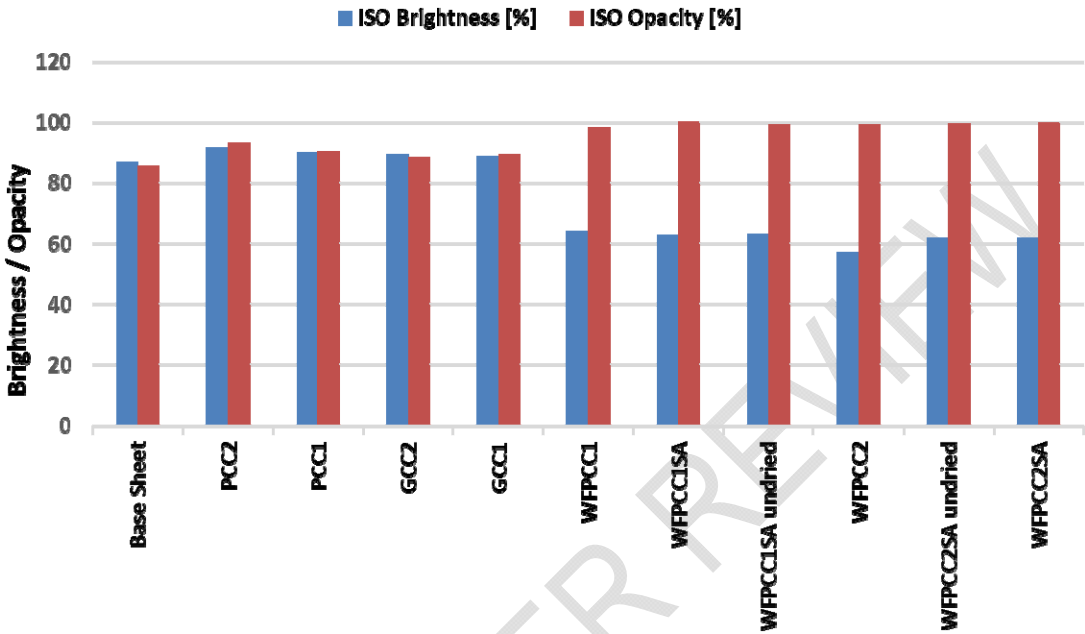
337 **Fig. 11. Brightness / Opacity 20% filler + WF**
338

339 Figure 12 shows the final produced handsheets with all four wood flour PCC slurries. Picture
340 12a (from up to down) WFPCC1, WFPCC1SA, WFPCC2SA, and WFPCC2. Picture 12b
341 shows the back sides of the handsheet in opposite direction.
342 The color differences were so significant that they were easily visible.
343
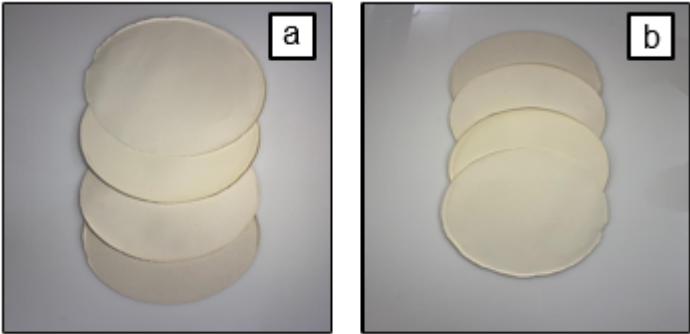
344 **Fig. 12. Handsheets Wood flour and PCC front a) back b)**
345

346 Figure 13 compares the L-/ a-/ b- values of the handsheets with a 20% filler level to the basis
347 sheet (L: 96.19 / a: -0.816 / b. 2.78).
348 The calcium based pure mineral fillers (PCC1, PCC2, GCC1, GCC2) are all in the same
349 range. In general, the L-value of all four papers is higher than the basis sheet, in a range of
350 97.7 to 96.47. Looking at the a-values, all four sheets appear less green/ redder than the

351 basis sheet. Ranging from -0.426 to -0.542. Comparing b-values, ranging from 1.77 to 2.34
352 with the handsheets containing filler, the basis sheet appears more yellow/ less blue.
353 Introducing wood flour to the filler blend lowers the L-, increases the a- and strongly
354 increases the b-value in comparison to the basis sheet.
355 The three handsheets containing WFPCC1 all have a very similar L- (89.35 to 89.55) and a-
356 (-0.69 to -0.76). The blend without SA has a b-value of 9.73, both sheets containing the
357 strengthener appear more yellow (11.04 and 10.08). Contact drying to activate the
358 strengthener does not interfere with the color.
359 The three handsheets containing WFPCC2 are lower in L-readings, WFPCC2 with the WF C
360 750 FP type being by far the darkest (84.9), the WFPCC2 types containing the SA have a L-
361 values of 88.23 and 88.2. Comparing a- and b-readings, all three papers lay within a very
362 narrow range (a: -0.21 to -0.03 and b: 9.58 to 9.77). The additional drying did not appear to
363 influence on the optical properties.
364
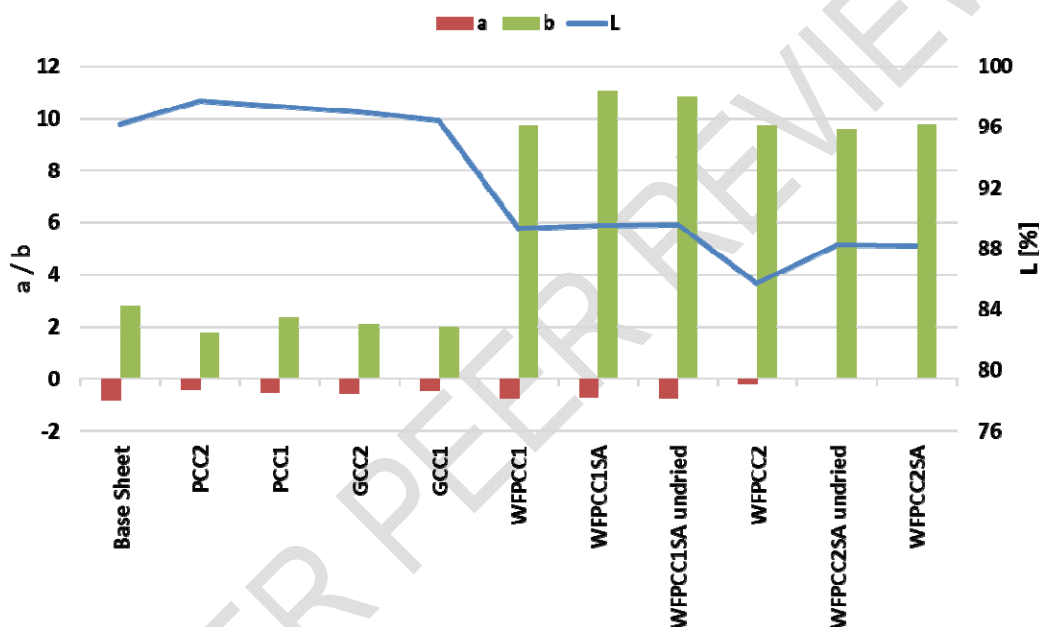
365 **Fig. 13. L - a - b 20% filler + WF**
366
367 **3.6 Suggestions**
368 During the research and the discussion of the results, several proposals are made for future
369 research projects, which could deal more intensively with partial aspects.
370 To compensate for the significant losses in brightness and whiteness, the wood flour could
371 be bleached.
372 Another possibility would be the comparison of low filler amounts. Smaller gradings would be
373 advantageous to achieve an ideal ratio. This is mainly because the best results were
374 achieved with the lowest amount of filler in this research work. One possible avenue for
375 further research is the usage of wood flour as a retention aid, specifically, determining how
376 little wood flour can be added yet still produce an appreciable effect. In this scenario, sheet
377 formation would be an area of interest; conventional retention aids (typically charged
378 polyacrylamides) tend to damage formation by flocculating the fibers. [25, 26] It would be
379 interesting to know if wood flour could aid retention without damaging formation
380
381

4. CONCLUSION

The main objective of this study is to investigate if wood flour can replace commercial mineral fillers for papermaking with a handsheet study. The handsheet study contains 25 different furnish mixtures. For the handsheet study, the base sheet contains a 80%SW/20% HW. The filler content in the use of wood flour and mineral fillers varied between 10, 15 and 20%.

The study showed that calcium carbonate precipitated in the presence of wood flower the retention of filler increased significantly up to over 92.68% whereas commercial PCC and GCC achieved a maximum of 8.66% and 34.77% respectively. The use of WFPCC resulted in a higher caliper of up to 208 μm compared to commercial GCC and PCC filler which achieved a caliper of 120.4 μm and 145.6 μm respectively.

Tensile and tear strength did not show an improvement for the WFPCC usage in comparison to the commercial GCC and PCC filler material. Usage of WFPCC with SA showed an improvement in comparison to WFPCC without SA.

Elongation and TEA could did not show an improvement for the WFPCC usage in comparison to the commercial GCC and PCC filler material. The WFPCC including the SA showed a clear improvement of plus 30% for the 15% filler containing handsheets. For the 20% filler-containing hansheets the improvement is only up to 2%.

The opacity of the paper was increased by the use of WFPCC of up to 10 opacity points to 100.46 compared to commercial filler material with a maximum opacity of 93.41.

The coloring of the filler has a significantly greater influence on the final color of the paper than the conventional fillers, even in small amounts. This has resulted in lower brightness of up to 30 brightness points compared to the commercial filler material. In addition and more yellow/cream tones of the paper could be observed.

Promising uses for this special filler type would be, for example, usage in corrugating medium grades, as properties such as stiffness and calipers play a major role in these grades. The optical properties, on the other hand, are rather irrelevant in the middle layer. For these reasons, these fillers could also be used as an internal layer of multi-ply, carton board and coaster board. Wood flour-containing fillers could facilitate the development of cream colored grades that use little or no synthetic dye. Coloring paper in this way could also be beneficial from an environmental and marketing perspective.

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